Space Weather Technical Forecast

Issued on Monday, 26 December 2022 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Potential Earth-directed CMEs on 26th, 27th and 29th with possible G1/Minor Storms and low risk of G2. Active electron fluence likely 26th.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the last 24 hours with only C-class flares observed. There are six sunspot regions on the visible disc. The largest and most dominant region remains 3169, which has shown some consolidation in the intermediate and trailing spots, with the threat of small delta spots forming in it's intermediate area. The neighbouring region AR3171 remains relatively stable though has a north/south magnetic alignment, and therefore will need to be monitored for any development. All other regions remained generally simple and stable, with no appreciable growth displayed by any group.

One CME occurred from the vicinity of AR3168 during a C9 flare early on 25th, this CME seems to be generally missing ahead and below, though it may give very slight impacts at Earth on 29th.

Solar Wind / Geomagnetic Activity: Solar wind speeds have fell from Strong to Slightly Elevated, from 650 km/s down to 400-500 km/s, though data quality from both ACE and DSCOVR has been questionable. Total magnetic field strength has risen from weak to moderate, ending around 9nT. The north-south component, Bz, was mostly negative, varying between +2/-9. Phi angle has been predominantly positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3) through the period.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels.

High energy electron flux (greater than 2 MeV), as observed by GOES16, varied between moderate to high (1e3 pfu) levels. Electron fluence has been on an increasing trend. 8.29e7 integrated pfu recorded at 26/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be mainly at Low levels, with a slight chance of M-class flaring, mainly from AR3169.

Solar Wind / Geomagnetic Activity: Three possible CMEs feature in the forecast period, two which left the Sun on 24th and one from 25th. Possible arrivals start from late on 26th into early 27th, then 29th. The HSS from CH56/+ is expected to continue to wane early in the period before the possible arrival of CH57/+ on 26th or 27th. The leading edge of the HSS from CH59/+ is possible from late 28th or more likely early 29th.

Geomagnetic activity is forecast to be mainly Quiet to Unsettled early 26th. Later on 26th and into 27th, Active or G1/Minor Storm intervals become likely, due to possible CME arrivals and a chance of these combining with CH HSS. There is a very slight chance of G2/Moderate Storms given the potential for a more direct arrival. Geomagnetic activity then likely becoming Quiet to Unsettled 28th, before a chance of further Active or G1/Minor Storm intervals on 29th due to either glancing CME or CH HSS arrivals.

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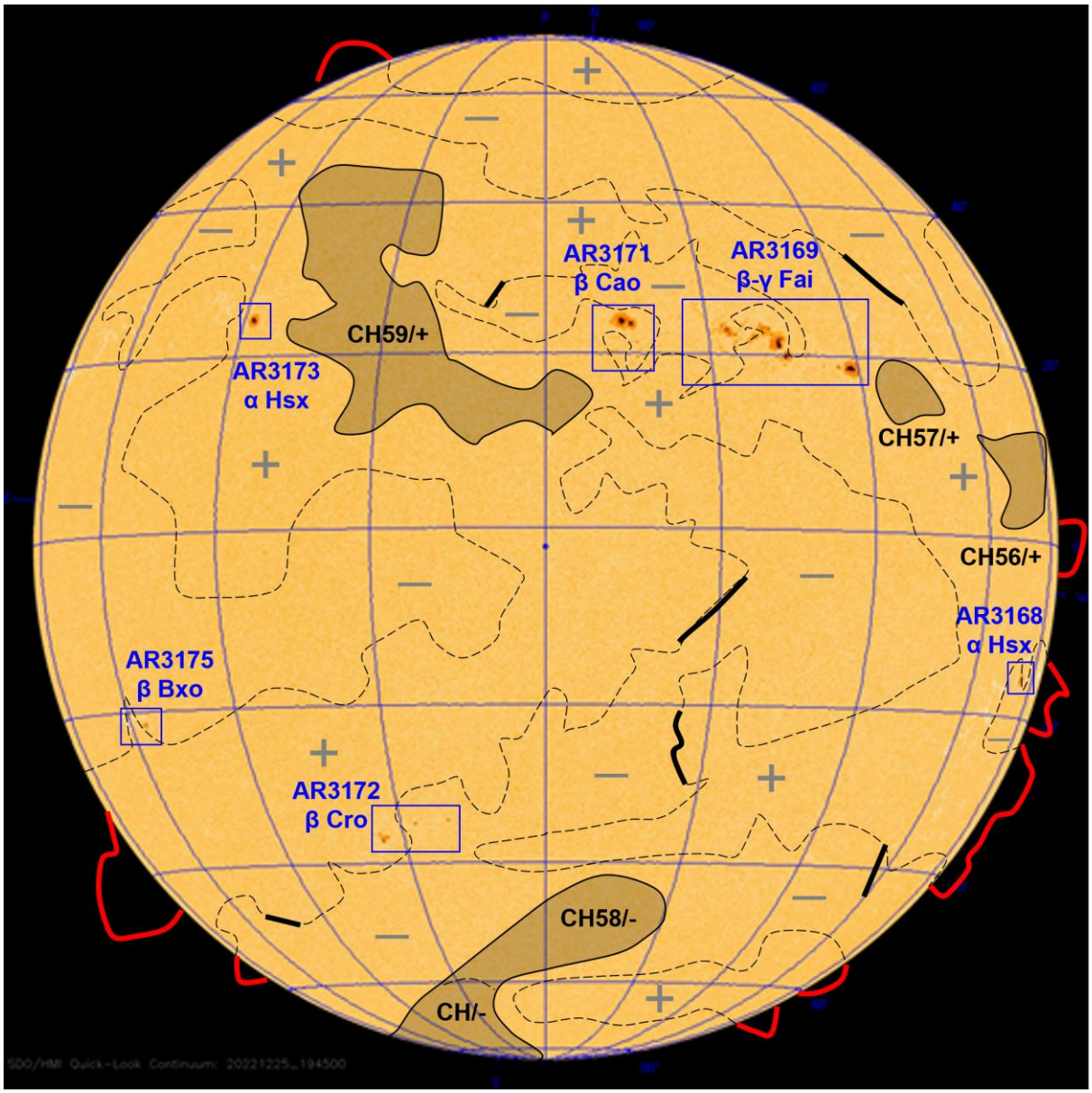
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, with only a slight chance of reaching S1 levels.

High energy electron flux (greater than 2MeV) may continue at moderate to high levels initially, though CME arrivals from late 26th onward could have the effect of redistributing electrons away from GEO orbits. Confidence is therefore low for the possible behaviour of electron flux over the next four days.

Electron fluence values are likely to breach the Active threshold during 26th, with the subsequent trend seeing lower confidence and dependent on potential CME arrivals from late 26th onward.

Figure 1. Solar Analysis Valid 25/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The next CME with a potential Earth-directed component left the northeast quadrant of the Sun early on 24th and may glance the Earth from late on 26th. Main uncertainties with this CME are the angular size of the cone and possible speeds, with a large margin of error across the Enlil ensemble. Given the location of the eruption, in the northeast, slight changes in initial parameters could have a significant impact on whether the feature affects Earth. A further CME which left the Sun from the southwest quadrant later into the morning of the 24th may arrive at Earth on 27th, although this is also low confidence due to limited imagery. The final eruption occurred from the vicinity of AR3168 during a C9 flare early on 25th, this CME seems to be generally missing ahead and below, though it may give very slight impacts at Earth on 29th.

The coronal hole high speed stream from coronal hole 56 is expected to continue to wane early in the period before a further small high speed stream may bring higher speeds into the 26th or 27th, but with low confidence, as the feature continues to weaken during the last 24hrs. Any further coronal hole connections may also be masked by possible CME arrivals. Potential affects from the leading edge of coronal hole 59 are possible from late 28th or early 29th.

Geomagnetic activity is forecast to be mainly Quiet to Unsettled early 26th. Later on 26th and into 27th, Active or G1/Minor Storm intervals become likely, due to possible CME arrivals and a chance of these combining with residual high speed stream connections. There is a very slight chance of G2/Moderate Storm given the potential for a more direct arrival. Any CME arrival on 27th could see residual storming persisting into 28 December, though forecast probabilities indicate that lack of confidence on this. There is then a chance of further Active or G1/Minor Storm intervals on 29th due to either glancing CME or CH HSS arrivals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	50	50	20	30
Strong	G3	No	5	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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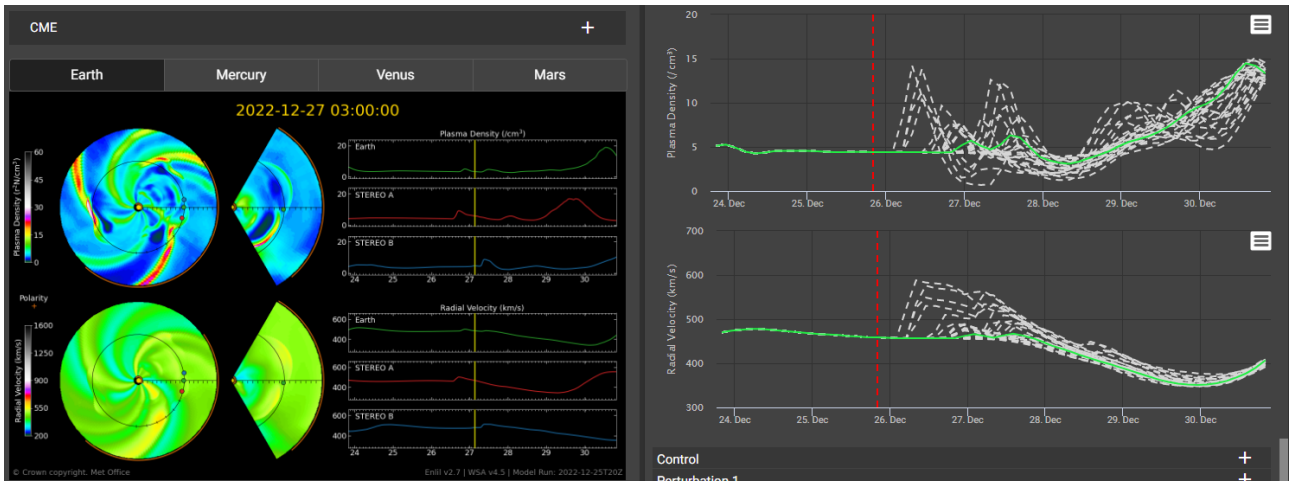
Figure 2: MOSWOC ENLL and Ensemble



Radio Blackouts - X-Ray Flares:

Solar activity has been Low, mostly associated with the large and complex AR3169 in the northwest quadrant through the last 36 hours. There have been a series of CMEs emanating from this region and signs of possible small delta spot formation, which may be a precursor for further development.

Activity has been generally below that expected of similarly complex regions, but a slight chance of M-class flaring is possible based on potential for further activity. Other active regions on the visible disk remain generally stable for now. Further regions are forecast to rotate onto the visible disc later in the period, based on analysis of far sided STEREO imagery and these will be analysed once any regions become visible.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	20	20	20	20
Very Active	R3 to R5 X Class	No	1	1	1	1

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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is expected to remain at Background levels.

Forecast probabilities remain at a very slight chance due to the possibility of any larger flares from AR3169.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is currently varying between moderate and high (1e3pfu) levels. This has coincided with a gradual weakening of the solar wind speeds and likely be a result of the radiation belts relaxing into their natural orbits following easing HSS influence.

The forecast is subject to notable uncertainty however, and further rise could be limited based on the strength of any potential geomagnetic activity from possible CME effects from late 26th onward that may have the effect of compressing belts and redistributing electron populations.

Electron fluence values are likely to breach the Active threshold during 26th, with the subsequent trend seeing lower confidence and dependent on potential CME arrivals from late 26th onward.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	70	50	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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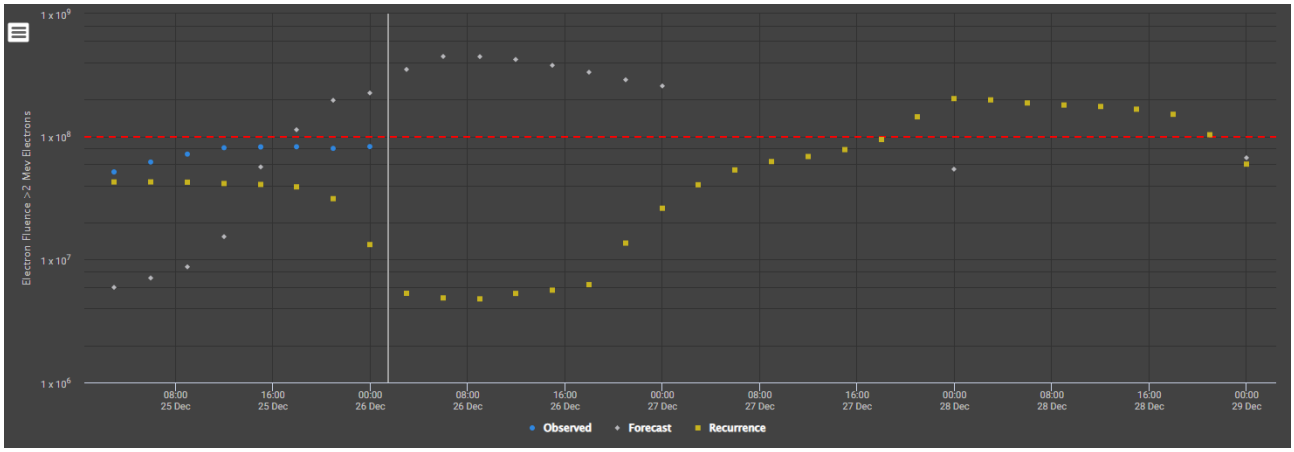
Figure 5:



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